CLAIMS

1. A crosslaminate comprising mutually bonded polymer films of which at least two neighbour films A and B each being coextruded films are uniaxially oriented or unbalanced biaxially oriented, whereby the main direction of orientation (2) in A crosses the main direction of orientation (3) in B and each contains a layer consisting of a polymer material selected for high tensile strength (hereinafter the main layer) and on each main layer on its side which faces the neighbour film A or B at least a first surface layer, characterised in that said first surface layer on each of the films A and B is a discontinuous layer consisting of an array of coextruded thin strands (101, 102), the strands (101) on A being arranged to cross the strands (102) in B, and the strands consisting of a material which is selected to modify the properties in the surface of the respective film, this modification concerning either the optical appearance of the laminate or the bonding between A and B or both.

2. A crosslaminate according to claim 1 characterised in that A and B are strongly bonded to each other in each spot (a) where a strand (101) on A intersects with a strand (102) on B, while A and B are weaker bonded or not bonded over the parts (b) of their contacting surfaces, which are devoid of any first bonding layer.

3. A crosslaminate according to claim 1 or claim 2, characterised in that the modification of optical appearance is established through a selection of pigmentation in the first surface layer.

4. A crosslaminate according to any of the preceding claims, characterised in that the thickness of the strands in each of said films A and B amounts at the highest to 30%, preferably at the highest 20% and still more preferably no more than 10% of the thickness of the respective film.

5. A crosslaminate according to any of the preceding claims, characterised in that the width of the strands in each of said films is selected to occupy at the highest 60%, preferably at the highest 50% and still more preferably at the highest 30% of the surface area of the respective film.

6. A crosslaminate according to any of the preceding claims characterised in that the thickness increase in each of said films A and B at the locations where the strands are coextruded amounts at the highest to 30% seen relative to the immediate surrounding, preferably at the highest 20% and still more preferably no more than 10%.

7. A crosslaminate according to claim 1 or claim 2 characterised in that the distance from middle to middle of neighbour strands in each array is between 2 mm and 80 mm, preferably no higher than 40 mm, and more preferably no higher than 20 mm.

8. A crosslaminate according to any of the preceding claims, characterised by a second surface layer (104, 105) on the main layer of at least one of the neighbour films A and B on the side of the main layer which faces the other one of the said neighbour films, this second surface layer being continuous and either located between the main layer and the first surface layer or on top of the first surface layer, and preferably selected for control of the bonding between A and B.

9. A crosslaminate according to claim 8 characterised in that the second surface layer is between the main layer and the first surface layer and is selected to produce, at locations (b) which are devoid of any first bonding layer, a bonding of lower strength than the bonding in the spots (1) where strands on A intersect strands on B.

10. A crosslaminate according to claim 2, characterised in that the bonding strength in the spots as measured by peeling, carried out on narrow specimens at a velocity of about 1 mm s^{-1} is at least 40 g cm^{-1} and the bonding strength in the parts of the contacting surfaces which are devoid of any first bonding layer, similarly determined is at the highest 75%, and preferably no more than 50%, of the bonding strength in the spots.

11. A crosslaminate according to claim 1, characterised in that it comprises two such pairs of array-bonded films A and B.

12. A crosslaminate according to claim 11, characterised in that one film is common for two such sets, this film having an array of the said strands on both of its surfaces.

13. A crosslaminate according to any of the preceding claims, characterised in that it comprises on one or each of the outer films of the laminate, a surface layer (106, 107) which also is surface layer of the laminate and is adapted to enhance heat-sealing of the laminate and/or increase its frictional properties.

14. A crosslaminate according to any of the preceding claims, characterised in that the main layer at least of each of the said two films A and B mainly consists of polyethylene or polypropylene.

15. A crosslaminate according to claim 14, characterised in that in each of said films A and B the main layer consists of HDPE or LLDPE or a blend of the two, the second bonding layer mainly consists of LLDPE but with admixture of 5-25% of a copolymer of ethylene having a melting point or a melting range within the temperature interval 50-80°C, and the strands mainly consist of a copolymer of ethylene having a melting point or a melting range within the temperature interval 50-100°C or a blend of such copolymer and LLDPE containing at least 25% of the said copolymer.

16. A crosslaminate according to any of the preceding claims characterised by the following further features:

a) it has a general thickness of at the highest about 0.3 mm,

b) A forms one surface of the laminate,

c) the laminate surface at least on the A-side exhibits a visible pattern of striations (103) along one direction constituted by surface corrugations with corresponding thickness variations in A, the divisions in said pattern being at the highest about 3 mm,

d) the thin strands are coloured, and the rest of the film A is sufficiently transparent to show the coloured strands when the laminate is observed from the A-side, whereby the depth of the

corrugations is sufficient to make the strands appear as being at least about 0.5 mm distant from the striations.

17. A crosslaminate according to claim 16, characterised in that the colour of the strands is formed by a pigment which supplies a metallic lustre or an iridescent effect.

18. A crosslaminate according to claim 16 or 17 characterised in that viewed in a cross-section perpendicular to the striations, the laminate exhibits a generally regular arrangement of ribs which are thicker than the average thickness of the laminate and have a generally concave and a generally convex surface to form a bending of the rib transverse of its longitudinal direction and in that the material in or adjacent to the boundaries of the ribs in the tensionless state of the material are bent in the opposite direction to the rib to give the material between the two adjacent ribs a generally straightened-out shape.

19. A crosslaminate according to any of the preceding claims and in which strong bonding is established where the strands intersect (a), while by means of a second surface layer between the strand formed first surface layer and the main layer in each of the films A and B, a weak bonding or a blocking is established in the areas (b) which are devoid of strand material, characterised in that said weak bonding or blocking is established by means of the addition in the second surface layer of an adhesion aid, preferably a low molecular weight polyisobutylene or polypropylene.

20. A crosslaminate according to any preceding claim in which the first surface layer on A and/or B comprises two or more sets of strands, each said set being formed of a material differing in composition and/or colour from the other set(s) and the strands of the sets being offset from one another.

21. A crosslaminate according to any preceding claim, characterised in that said first surface layer on each of the films A and B occupies at the highest 15%, preferably at the highest 10%, and more preferably at the highest 5% of the volume of the respective film A or B.

22. A crosslaminate according to any preceding claim, characterised in that the average melting point of the polymers which constitute the strand formed first surface layer, is at least about 10°C, preferably at least 15°C, and more preferably at least about 20°C lower than the average melting point of the polymers which constitute the main layer.

23. A method of manufacturing a crosslaminate comprising mutually bonded polymer films of which at least two neighbour films A and B each are formed by coextruding in a flat or circular die a main layer of a polymer material which is selected for high tensile strength and a first surface layer from a polymer material, and in which A and B each is supplied with a uniaxial or unbalanced biaxial molecular orientation at any stage after the joining of the different materials in the coextrusion die and before the lamination, and prior to the lamination A and B are arranged in such a way that the main direction of orientation in A will cross the main direction of orientation in B, and during the lamination the bonding between A and B is established at least in part through heat, characterised in that in the coextrusion each of the said first surface layers is made discontinuous in the transverse direction, whereby it consists of an array of strands, and A and B are arranged so that the array of strands on A cross the array of strands on B, and further characterised in that the material from which the strands are extruded is selected to modify the properties in the surface of the respective film, this modification concerning either the optical appearance of the laminate or the bonding between A and B.

24. A method according to claim 23 characterised in that in the lamination the heat is applied generally evenly all over A and B the selection of polymer materials is adapted to make the strands on A strongly bond to the strands on B in the spots where they intersect the latter but make a weaker bonding or avoid bonding over the parts of the contacting surfaces, which are devoid of any first bonding layer.

25. A method according to claim 23 or 24 in which the coextrusion of at least one of the films A or B is carried out by means of circular

coextrusion die, to form and draw-down a tubular film, characterised in that the draw-down is adapted to produce a significant uniaxial or unbalanced biaxial melt-orientation with the main direction of orientation and the direction of the array of strands either extending along the longitudinal direction of the film or, by means of a relative rotation between the exit of the die and means to take up the film after the extrusion, the main direction of orientation is made to extend helically along the tubular film, and subsequently the film is cut open under an angle to the main direction of orientation and to the direction of the array.

26. A method according to claim 25 characterised in that the distance from the middle to middle of neighbour strands at the exit from the extruder is at the highest 8 cm, preferably no higher than 4 cm and more preferably no higher than 2 cm, and the circumference of the tube at this exit is at least 20 cm.

27. A method according to any of claims 23 to 26 characterised in that following the bringing-together of the films in a sandwich arrangement for lamination, before, after or simultaneously with the bonding of said sandwich arrangement to a laminate by heat, the films are further oriented by stretching in the longitudinal and/or in the transverse direction.

28. A method according to any of claims 23 to 27 characterised in that in the coextrusion process, A and/or B is/are also supplied with a continuous second bonding layer which is coextruded on the main layer under the array of strands, whereby the said second bonding layer consists of a polymer material different from those in the main layer and the first bonding layer, selected to produce, during the lamination, bonding also at locations which are devoid of any first bonding layer, but a bonding of lower strength than the bonding in the spots.

29. A method according to any of claims 23 to 28, characterised in that in the lamination process the strands in A are directly sealed to the strands in B.

30. A method according to any of claims 23 to 28, characterised in that the lamination process is extrusion lamination whereby the bonding is established by means of a separately extruded layer.

31. A method according to any of claims 23 to 30 characterised in that arrays of strands are coextruded on both sides of A and B films are arranged on both sides of A with the array on each film B crossing the array on the respective side of A.

32. A method according to claim 28 in which in addition to the films A and B there is applied at least one more film in the lamination, characterised in that said film also is produced by coextrusion and thereby is provided with a surface layer of a composition adapted to control its bonding in the laminate, whereby this composition and the lamination conditions are chosen such that the strength of this bonding becomes higher than the bonding strength between A and B at the locations which are devoid of the coextruded strands.

33. A method according to any of claims 23 to 32, characterised by the following further features:

a) the thicknesses of the films used to make the laminate and the stretch ratios are adapted to give the final laminate a general thickness of at the highest about 0.3 mm,

b) A is applied as one surface of the laminate,

c) the laminate surface at least on the A-side is embossed to form a visible pattern of striations along one direction constituted by surface corrugations with corresponding thickness variations in A, the divisions in said pattern being at the highest about 3 mm,

d) the material for the strands is coloured, and the rest of the film A is maintained sufficiently transparent to show the coloured strands when the laminate is observed from the A-side, whereby the depth of the corrugations is made sufficiently deep

to give the strands the appearance of being at least about 0.5 mm distant from the striations.

34. A method according to claim 33 characterised by the embossing involving passing the films of the laminate, when they have been brought together for lamination, before or after establishment of the bonding, through one or more pairs of mutually intermeshing grooved rollers, by which the embossing step also stretches the laminate.

35. A method according to any of claims 23 to 34, characterised in that said first surface layer on each of the films A and B occupies at the highest 15%, preferably at the highest 10%, and more preferably at the highest 5% of the volume of the respective film A or B.

36. A method according to any of claims 23 to 35, characterised in that the average melting point of the polymers which constitute the strand formed first surface layer, is at least about 10°C, preferably at least 15°C and more preferably at least about 20°C lower than the average melting point of the polymers which constitute the main layer.

37. A circular extrusion die comprising a distribution part (8) in which at least a first molten polymer material can be formed into a generally even circular flow, and bodily separate from this an exit part (9) comprising a circular main channel (12) with generally cylindrical or conical walls, which channel may comprise a flat zone, to conduct said molten polymer material towards an exit orifice from which it will leave the die as a tubular film structure (16), characterised in that said exit part also comprises a channel system (10) for circumferential extrusion of a circular array of narrow strands of a second molten polymer material, said channel system ending in a circular row of internal orifices (11) in the outward generally cylindrical or conical wall of the main channel.

38. A circular extrusion die according to claim 37, characterised in that said circumferential extrusion starts at one or a few inlets (13) to the exit part and comprises for equal dividing a labyrinthine channel system (10)

starting at each inlet, each such system comprising at least three channel-branchings.

39. A circular extrusion die according to claim 38, characterised in that the channels of the labyrinthine system or systems terminate in a common circular channel having a wall common with a part of the generally cylindrical or conical wall of the main channel (12), the circular row of internal orifices (11) being located in said wallpart.

40. A circular extrusion die according to any of claims 37 to 39, characterised in that the circumference of the inward wall at the exit is at least 20 cm, and the distance from middle to middle of neighbour orifices in the circular row is adapted to produce, after the magnification or reduction which will happen if the walls of the main channel are generally conical, a distance from middle to middle of neighbours of the strands which is at the highest 8 cm, preferably no higher than 4 cm and more preferably no higher than 2 cm.

41. A circular extrusion die according to any of claims 37 to 40, in which additionally to the means for coextruding the said first and second molten polymer materials there are means for coextruding a circular flow of a third molten polymer material on the side of the first material which is opposite the second material, characterised in that channel arrangements for joining the flows of first and third materials are provided either in the said distribution part, or in a part between the latter and the bodily separate exit part.

42. An apparatus for manufacturing a cross laminate comprising die for coextruding film A and a die for coextruding film B, the or each said die comprising a first distribution part (8) in which a first molten polymer material can be formed into a generally even flow, a second distribution part (9) in which a second molten polymer material can be formed into a flow, an exit orifice, an exit part comprising a main channel (12) to conduct said first molten polymer material towards the exit orifice and a channel system (10, 11) at one side of said main channel to conduct said flow of second molten polymer material to form a surface layer on one side of the flow of said first

molten material towards the orifice, wherein the coextruded material leave the exit orifice of the die as a film structure (16);

means for orienting A and B uniaxially or unbalanced biaxially after exiting the exit orifice;

means for arranging the oriented films A and B such that the said surface layers face one another and such that their directions or main directions of orientation cross one another; and

laminating means for laminating A and B by application of heat;

characterised in that the channel system for conducting the second polymer material provides a flow of said second material which is discontinuous in a direction generally transverse to the flow direction whereby each of the surface layers of A and B is formed as an array of strands and when the films A and B are arranged with their surface layers facing one another the strands on A cross the strands on B.

43. Apparatus according to claim 42 in which the or each said die is a circular die according to any of claims 37 to 41.

44. Apparatus according to claim 42 or 43 in which the laminating means apply heat across the entire width of A and B.

45. Apparatus according to any of claims 42 to 44 in which the or each said die is a circular die and comprises draw-down means for the tubular film which provides significant melt-orientation with the direction or the main direction of orientation and the direction of the strands extending in the axial direction of the tubular film.

46. Apparatus according to any of claims 42 to 44 in which the or each said die is a circular die and comprises film take-up means which optionally rotate relative to the exit orifice whereby a main direction of orientation of the film is helical along the tubular film and which further comprises cutting means for cutting the tube at an angle to the main direction of orientation and to the direction of the array of strands.

47. Apparatus according to any of claims 42 to 46 which further comprises means for stretching the films A and B upstream, downstream or

at the same point as the said laminating means, in a longitudinal and/or transverse direction.

48. Apparatus according to any of claims 42 to 47 in which the arranging means are adapted such that said surface layers in A directly contact said surface layers on B.

49. Apparatus according to any of claims 42 to 47 in which the arranging means comprise means for extruding a laminating layer between the surface layers of A and B.

50. Apparatus according to any of claims 42 to 49 which further comprises

In a die for producing A, a channel system at each side of the main channel for A which conducts said second polymer material in a flow which is discontinuous in the transverse direction whereby surface layers are formed on both sides of film A as arrays of strands and wherein a film B is arranged on each side of film A with its surface layer facing A whereby the strands of each film B cross the strands of A on the side which faces the respective film B.

51. Apparatus according to any of claims 42 to 50 which further comprises embossing means for embossing film A downstream of the die exit with a pattern of striations constituted by corrugations and corresponding thickness variations in film A, with the striations being separated by no more than 3 mm.

52. Apparatus according to claim 51 in which the embossing means is located downstream of the means for arranging films A and B and comprises one or more pairs of intersecting grooved rollers which stretch the films passing between them.